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Quarterly Technical Summary

Educational Technology Program

15 December 1971

Prepared under Electronic Systems Division Contract F19628-70-C-0230 by

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Lexington, Massachusetts

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ABSTRACT

The first three of the prototype terminals that will be used in the field tests at Keesler Air Force Base were completed during this quarter and are being operated in full system shakedown tests. The microfiche production facility has been completed, and preparation and production of lesson materials for the Keesler Trial are proceeding on schedule.

F.C. Frick
Program Manager

15 December 1971

Accepted for the Air Force
Joseph R. Waterman, Lt. Col. USAF
Chief, Lincoln Laboratory Project Office

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F. C. Frick

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Goodman, L. M.
Grossberg, M.
Harris, W. P.
Karp, D.
LaFrey, R. R.
Ruyle, A.
Selfridge, O.G.

Assistants

Gagnon, J. V.
Giltner, Carol A.
Hallowell, L. F.
Pugh, Barbara K.
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Technicians

Delsie, J. V.
Edman, E. W.
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Technical Staff

DeSantis, F. G.
Ralowicz, E. D.
Sanderson, A. M.
Stuart, D. G.
Wright, S. H.

Assistants

Roberts, A. V.
Staffiere, A. R.

EDUCATIONAL TECHNOLOGY PROGRAM

I. EDUCATIONAL DEVELOPMENT PROGRAM FOR LTS

A. Conditions of Keesler Trial

The purpose of the Keesler Trial is to demonstrate a new and educationally powerful training system. The Lincoln Training System (LTS) contains elements of both audio-visual and computer-aided instruction, and it presents a considerable challenge to the author. To remedy errors and to take advantage of the full power of the machine requires iteration of the lesson development cycle. The Trial consists of about three months of operation, instructing in one week of an Air Traffic Control Course and one week in Principles of Electronics. During this period, it seems reasonable to keep altering the materials and student handling procedures to improve system performance. There are operational constraints that must be observed, however, if the over-all evaluation is to remain valid.

(1) Tutoring and lecturing by instructors must be extremely limited. Individualized instruction implies that grouping students or extensive recourse to an instructor to give individual help are not feasible.

(2) Maximum use of performance measures provided by LTS must be made. The minute-to-minute guidance provided within each lesson will have to be revised when serious failures are observed. The lesson performance profiles must be calibrated early in the experiment, used to evaluate individual students, and revised if they fail.

(3) Proper selection of subjects and other experimental control requirements must of course be met.

A lesson development phase is normal in systems of this kind, and there is no reason to believe that it can be ignored here. It is clear that significant difficulties can occur; occasionally the method and course materials will fail to perform correctly. The Keesler team must therefore be prepared to carry out "improvement" operations:

(1) Refurbishing of lessons should they fail all students,

(2) Provision of alternate and supplementary material for students who are slow, have limited math or reading skills, and the like,

(3) Calibration and revision of lesson performance profiles,

(4) Training in instructional monitoring techniques. This activity will provide experience at the Keesler Technical Training Center (KTTC) in the problems of conducting individualized instruction for the "average" student.

B. Preparation of Lessons for Keesler Trial

Preparation of lesson materials for the Keesler Trial of LTS is proceeding on schedule. Virtually all the visual display art work has been completed. On two occasions, members of the Keesler lesson development team visited Lincoln Laboratory to record audio messages associated

with the visual images. About half of these have been completed. Logic, in the form of tabular specifications of actions to be taken on each frame, has been prepared for several of the lessons in both Air Traffic Control and Principles of Electronics courses. The first version of the Lincoln Terminal Language Processor and Time-Sharing Monitor, which calls frames and interprets student inputs according to author specification, has been placed in operation and runs a prototype terminal. Shortly audio-visual fiche, lesson logic resident on magnetic tape, and the terminal on-line to the computer will be put in full operation for running through and debugging lessons.

The Educational Technology Group is developing two short lesson units as part of the material that will be used for the Keesler Trial. One of these is concerned with the behavior of series resonant circuits; it will be incorporated into the basic electronics curriculum. The other unit, part of the Air Traffic Control curriculum, is concerned with pilot reporting of weather conditions. These units will be ready for use by the time the Keesler equipment is activated.

C. New Author Programs

New programs were written in Lincoln Terminal Language to mediate student-initiated changes of pace and direction in the LTS.

When the student is working in the main index of courses and lessons, he can request transfer to the first frame of a lesson by inserting its number. Similarly, once he is in the lesson, the index function allows him to transfer to individual frames within. The locations that he can access are designated by the author as specifications to the program during the access frame. The error light signals when the student inadvertently wanders outside the area that he is expected to access.

If a student experiences some difficulty while he is interacting with a lesson, he can transfer to an intermission frame. Then, he may press HELP, which produces a record of his progress in the lesson up to that time, and leave the terminal to consult with the instructor. To exit from the lesson, the student transfers to a particular frame, where he gives his identification number. A program responds by producing a record of his progress and by transferring him back to the main index. There the student may select another lesson or inactivate the terminal.

II. HARDWARE DEVELOPMENT

During this quarter, an experimental terminal and three prototype terminals were constructed and have been operated in full system shakedown tests. Preliminary tests results indicate that satisfactory audio and visual performance will be achieved. The LTS-3 microfiche card production facility was completed during this quarter, and approximately fifty master course cards have been produced.

A. Terminal Design

Numerous modifications to the Image Systems, Inc. reader, in addition to those described in the previous Quarterly Technical Summary, were necessary to provide reliable operation. A dashpot was added to the film gate actuating mechanism to allow final positioning of the x-y table before gate closure. Linkages to insure equal motion of the two sides of the positioning mechanism were installed in order to eliminate intolerable flexibility in the x-y table itself. A separate reference power supply was utilized to eliminate coupling between the x and y main and vernier servos, and an isolation amplifier to reduce nonlinearities caused by loading the page selection

voltage divider was added. Also, in order to extend the effective range of vernier positioning, the x and y table servos will be further modified to provide self-selected coarse and fine control in place of the existing summed error configuration.

Interior views of the LTS-3 terminal are shown in Fig. 1. The audio reader assembly with on-board electronics rotates at 120 rpm in a clockwise direction, driving the signal track diode assembly along a circular path. An "Audio-On" signal from the computer enables the track servo system and the diode assembly is driven in along the spiral audio record. Two blank tracks (1 second) are recorded for track acquisition, but measured acquisition time is less than 0.1 second. Thus, the signal diode is on track well before the audio message starts.

A stationary coherent fibre light pipe is shown mounted in the center of the rotating reader assembly. The audio frame boresight target is imaged onto this pipe, and the light signal is conducted through the hub of assembly to a quadrant diode sensor mounted on the rear. The diode develops vernier x-y error signals for final positioning of the main x-y servo system. The rms acquisition errors in x and y have been as low as 0.0005 inch, but in general are better than 0.001 inch. This limits the maximum frequency deviation in playback to ±1%.

The dual film gate shown in Fig. 1 is actuated slowly, allowing the x-y servo system to position the film before the gate is actually closed, thus minimizing damage to the film surfaces.

B. Microfiche Production

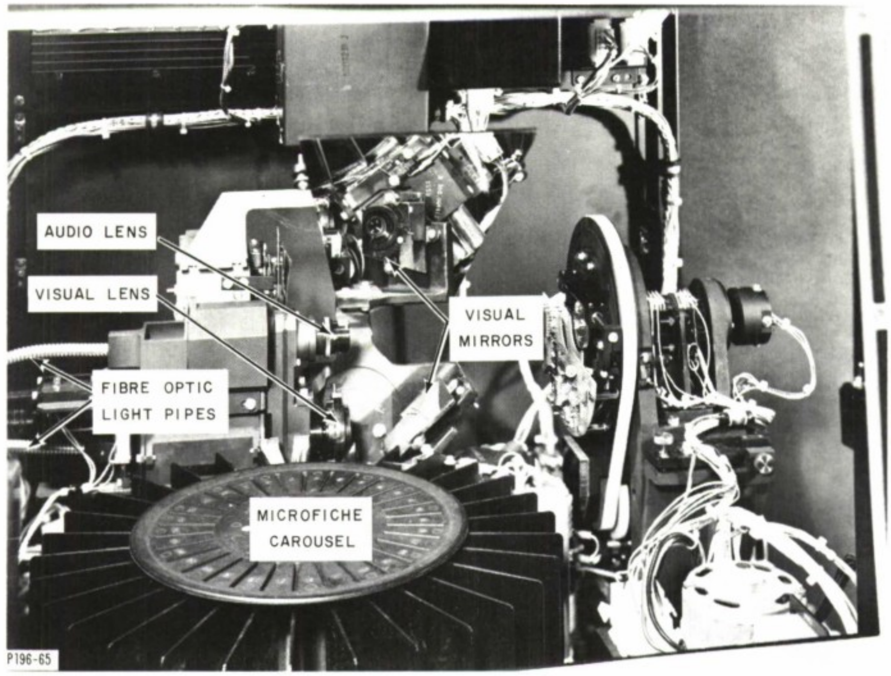
A functional block diagram of the LTS-3 microfiche production facility is shown in Fig. 2. KAFB author's audio and graphic instructional material are photographically processed to produce a precisely formatted array of 24 frames on a 4- by 6-inch microfiche card, shown pictorially in Fig. 3. Copies of each master lesson card are obtained commercially, then fitted with coded clamps for use in the student terminals.

A special purpose step and expose camera system was obtained during this quarter for the production of master microfiche lesson cards. The system consists of a copy plane transilluminator, a stress relieved support base, a Micro-Nikkor 150-mm lens, blade shutter, and a precision step-and-expose camera back.

The input material of the system consists of 8- by 10-inch negative transparencies, containing audio spiral images, and black-white visual images. The technique for producing the audio spiral images was described in the Quarterly Technical Summary dated 15 June 1971. Author visual material is furnished in the form of $8\frac{1}{2}$- by 11-inch paper with typed text and/or line drawings, and is photographically reduced 2.3:1 using a conventional studio camera and vacuum copy plane, onto Contrast Process Ortho Type 4154 film. Author $8\frac{1}{2}$- by 11-inch glossy prints with continuous grey scale are reduced 2.3:1 onto Kodalith Ortho Autoscreen 2563, a halftone film. The audio spiral masters and the visual masters are prepunched with registration holes which are used to align the masters on pin guides of the camera copy plane.

The important features of the camera system are high resolution (200 line pairs/mm) and precise image registration. The characteristics and performance of the system are shown in Table I.

The system is operated in a Class 100,000 clean room with temperature and humidity control, while the other photographic operations are performed in a controlled temperature and humidity environment. Special care is taken to minimize handling of all film to reduce defects caused by dust and lint on the emulsion surfaces. The master microfiche cards are being kept "acceptably" clean through the contact copying process, and contact copies are initially clean.



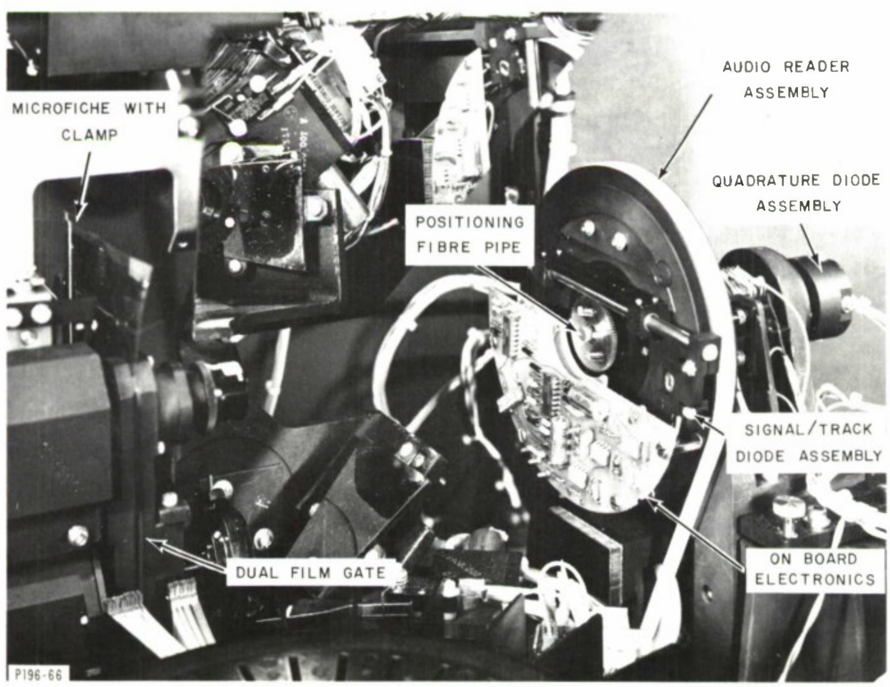


Fig. 1. LTS-3 reader system assembly.

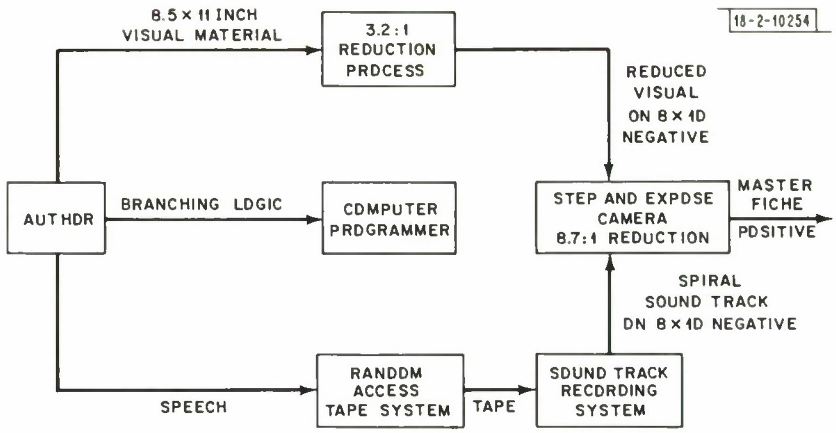


Fig. 2. LTS-3 microfiche production system.

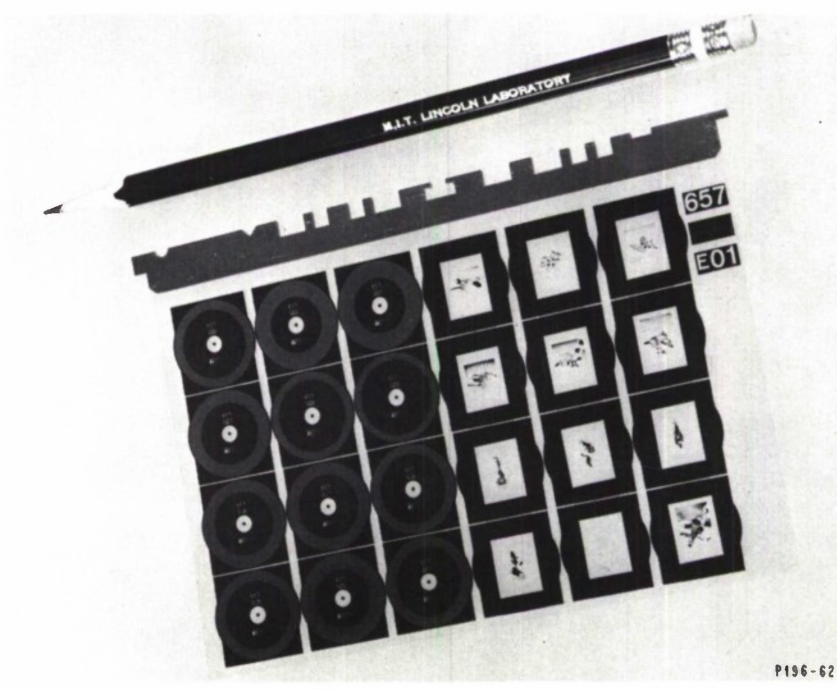


Fig. 3. LTS-3 microfiche lesson card.

TABLE I

STEP AND EXPOSE CAMERA CHARACTERISTICS

Transilluminator

Type: Aristo F810 with circumferential vacuum grove and registration pins designed to hold 8- by 10-inch transparency copy.

Uniformity: ±4 percent over total illuminator.

Camera

Lens: Micro-Nikkor 150 mm f/5.6 lens.

Reduction Ratio: 1:8.7

Resolution : Better than 187 line pairs per mm over the 22.3- by 22.3-mm field of each frame; performance holds over all 24 frames in the 105- by 148.75-mm fiche. Resolution stated is that which can be visually sensed under 150 power magnification, which is approximately the 3 percent level on a modulation transfer function (MTF) curve.

Exposure Control: Solenoid-actuated blade shutter.

Step and Expose Film Back

Film: Kodak Minicard 6451, 105 by 148.75 mm.

Film Mounting: Vacuum hold-down with registration pins.

X-Y Motion: Stepper motor actuated precision lead screws; each step represents 0.010 mm of translation.

Control: Solid state controller sequences through 24 frame locations and a title block; each movement and exposure is operator initiated.

Alignment

Film back is normal to optical axis of lens and parallel to transilluminator to within ±15 arc-seconds for any position of x-y table over area of microfiche.

Stepping Accuracy

Total error in frame location with respect to reference corner of master fiche film is less than ±0.075 mm.

* * *

After some machine handling, the cards pick up dust and lint, and this adds impulsive noise to the otherwise "quiet" audio channel. We are presently investigating techniques for reducing the effects of dust-induced impulse noise.

We have been producing microfiche masters for approximately three weeks and will continue at the rate of 25/week (24 frames/master). We plan to have all the KAFB author material on microfiche by January 1972.

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14. KEY WORDS

educational technology	microfiche production
Lincoln Training System (LTS)	computer-aided instruction